

**Intraoperative Angiography via the Popliteal Artery: A Useful Technique for
Patients in the Prone Position**

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ABSTRACT

OBJECT Intraoperative angiography can be a valuable tool in the surgical management of vascular disorders in the central nervous system. This is typically accomplished via femoral artery puncture, however this approach can be technically difficult in patients in the prone position. We describe the feasibility of intraoperative angiography via the popliteal artery in the prone patient.

METHODS This is a case series of three patients undergoing intraoperative spinal angiogram in the prone position via vascular access through the popliteal artery. In all three patients, standard angiography techniques were used, along with ultrasound and a micropuncture needle for initial vascular access. Two of the three patients underwent intraoperative angiogram to confirm the obliteration of dural arteriovenous fistulas. The third patient required unexpected intraoperative angiogram when a tumor was concerning for a vascular malformation in the cervical spine.

RESULTS All three patients tolerated intraoperative angiography via the popliteal artery without complication. Accessing the popliteal artery was easily obtained without any adaptation to typical patient positioning for these prone cases. The technique proved particularly beneficial in the case in which angiography was not part of the preoperative plan.

CONCLUSIONS Intraoperative angiography via the popliteal artery is feasible and is well tolerated. It presents significant benefit when imaging patients in a prone position, with the added benefit of easy access, familiar anatomy and low concern for catheter thrombosis or kinking.

Digital subtraction angiography (DSA) is an invaluable tool for the treatment of vascular pathology in the nervous system. Its use before, during, and after surgical intervention provides the opportunity for pre-operative planning, as well as confirmation that the appropriate intervention has been completed. Its use is well-established in the treatment of intracranial pathologies such as aneurysms^{1,11} and arteriovenous malformations,^{8,16,17} as well as in spinal pathology, most often dural arteriovenous fistulas (dAVF).^{7,9}

The most common patient position for DSA is supine, offering easy access to the femoral artery. Intra-operative vascular access in spine surgery creates a challenge for vascular access, as patients are often prone. Though it has been described, femoral access in a patient positioned prone or lateral adds significant challenges to the procedure, including poor sterility at the access site and thrombosis or kinking of the sheath.¹⁰ Authors have also described obtaining vascular access in the upper extremities through either the brachial or radial artery.^{10,12} This approach, however, does have its limitations, mainly difficulty with navigation across the aortic arch and access to the left common carotid artery when coming from the left upper extremity.¹²

We describe three cases in which popliteal artery access was used to perform intraoperative spinal angiograms. Popliteal canalization has been described for the treatment of peripheral vascular disease,^{3,5,21} but to the best of our knowledge, this is the first description of its use for intraoperative angiograms in the treatment of neurovascular pathology. This is a feasible approach that offers easy vascular access to the interventionist and has little associated risk.

METHODS

This case series includes three patients who underwent intraoperative spinal angiography via popliteal artery puncture. In the first two patients, standard techniques were used to perform the angiogram with the exception of point of puncture. In the case of the first patient, the patient's popliteal fossa was prepped and draped in a sterile fashion using standard draping. A sterile hemostat was clipped to the edge of the drape lying over the fossa. The area in which the spinal surgery would take place was then prepped and draped in sterile fashion. The spinal draping was placed over the popliteal drape. When the time came for the angiogram, the popliteal fossa was easily found by palpation of the hemostat. The spinal draping over the hemostat was cut, exposing the still sterile angiogram drape. In the case of the third patient, where an intra-operative angiogram had not been planned, the spinal draping was then cut to expose the popliteal fossa. This area was then prepped and draped with standard angiogram draping. A C-arm was then brought into the OR and draped for all cases. The popliteal artery was accessed with a micropuncture kit, then a 5-French sheath was introduced, through which diagnostic catheters were advanced to the area of interest using standard guide wire techniques. Ultrasound was used to access the artery with the micropuncture needle in all cases. Standard AP and lateral angiograms were then completed. After completion of the angiogram, the microcatheter and sheath were withdrawn and hemostasis was obtained by applying direct pressure to the puncture site. In one case, a Femoral Introducer Sheath and Hemostasis (FISH) device was utilized. The remainder of each spinal surgery was then completed in standard form.

The first patient is an 81-year-old female who presented with slowly progressive gait and bladder dysfunction. This eventually led to imaging of the thoracic spine, which demonstrated the presence of tortuous veins and T2 prolongation (Figures 1A and 1B). A subsequent spinal angiogram revealed an arteriovenous fistula at the level of L4 on the right (Figure 1C). Due to the patient's clinical and radiologic findings, it was decided to pursue surgical obliteration of the fistula. The patient was then taken to the operating room and placed in a prone position. After the draping technique described above was completed, a midline incision was made overlying the L3 and L4 lamina, and an L3-4 laminectomy was performed. The dura was then opened and an arterialized vein was appreciated entering the thecal sac at the level of the right L4 foramen. A temporary clip was applied to the vessel and an intraoperative angiogram was obtained using our previously described popliteal technique (Figure 1D). This confirmed closure of the fistulous connection. The vessel was then coagulated and cut and the wound was closed using standard techniques. The patient recovered without any new deficits and no evidence of complication from the popliteal puncture. At 8 years post-procedure, the patient has shown no chronic complications for her popliteal access.

The second patient is a 48-year-old female who presented with progressive right leg weakness and gait difficulties. MRI of her spine showed marked dilation of her dorsal venous system, concerning for a dural AV fistula. This concern prompted a spinal angiogram, which confirmed the presence of the fistula at T5 (Figure 2A). Because of these symptoms and angiogram findings, the patient was taken to the operating room for surgical obliteration of the fistula. The patient was positioned prone and the popliteal fossa was prepped and draped as described above. The patient's thoracic spine was then

prepped and draped, and a midline incision was made followed by a T5-6 laminoplasty. The dura was opened in a normal fashion and a few small arteries were identified around the T5 nerve root. These were transected after bipolar cautery. At this point, it was thought the fistula had been obliterated, so an intraoperative angiogram was performed through the popliteal artery as described above. Unfortunately, the angiogram showed the fistula was still patent (Figure 2B), so further dissection was performed anteriorly. This revealed another artery. A clip was placed on this vessel, which did not affect somatosensory evoked potentials and motor evoked potentials monitoring. Because monitoring remained stable, this vessel was cauterized and cut. A repeat angiogram confirmed obliteration of the fistula (Figure 2C). The patient was closed in a standard fashion. The patient tolerated the surgery well and was neurologically intact post-operatively. She showed no complications from the popliteal angiogram. At 3 years post-procedure, the patient has shown no long-term effects from her popliteal access.

The third patient is a 34-year-old female who presented with slowly progressive weakness involving all of her extremities over the course of 18 months. The patient also endorsed paresthesias in all four extremities that had begun 4 years prior to presentation. Due to a difficult social situation, she had limited access to healthcare and had not undergone a thorough work-up. Her symptoms continued to progress to the point where they were causing significant difficulty with functioning independently. On exam, the patient was antigravity in her left upper and lower extremity and could weakly resist in her right upper and lower extremity. An MRI demonstrated a syringomyelia in the cervical spinal cord, with a weakly enhancing lesion behind the fourth cervical vertebra (Figures 3A–D). This was felt to represent an intramedullary neoplasm and plans were

made to take the patient to the operating room for tumor resection with the use of motor and somatosensory evoked potentials. She was placed in a prone position with her head in a Mayfield apparatus. The mid-cervical spine was exposed and laminoplasty was performed from C3-5. Upon opening the dura, there was a large, tortuous vein that had not been visualized on pre-operative imaging. It seemed to be originating in the vicinity of the fifth cervical root on the left side, so there was concern that it may be an arteriovenous fistula. In this case, pre-operative suspicion for vascular pathology was low, so preparations for an intraoperative angiogram had not been made. Because angiography was necessary to rule out vascular pathology, the draping over the popliteal fossa was cut and the fossa was prepped and draped with angiogram draping. Using the popliteal access technique described above, a vertebral artery angiogram confirmed the absence of any vascular pathology (Figure 3E). The procedure then proceeded as planned with a midline myelotomy and biopsy. Frozen section suggested a diagnosis of pilocytic astrocytoma, and a subtotal resection was performed due to a lack of a clear plane between the lesion and the spinal cord. Somatosensory potentials were never able to be obtained and motor evoked potentials actually improved through the case. The patient continued to improve through hospitalization and was able to be discharged to an acute rehabilitation facility. She did not have any evidence of complication from the angiogram after the procedure. Long-term complications were unable to be ruled out as this patient was lost to follow-up.

DISCUSSION

DSA is the gold standard procedure to confirm the complete obliteration of neurovascular pathologies such as aneurysms, arteriovenous malformations (AVM) and dural

arteriovenous fistulas (dAVF).^{2,4,8,22} Often, it is most helpful to perform the angiogram intra-operatively, to confirm elimination prior to the completion of the surgery. In cases when the patient is positioned supine, femoral artery access is easily obtained. Various methods for intraoperative angiogram in lateral or prone positions have been described in neurosurgical patients.^{10,12} Lang et al. compared femoral access to the transradial approach in three-quarters lateral and prone patients.¹⁰ They showed both approaches were acceptable, but each had its advantages and disadvantages.¹⁰ The primary advantage to the transfemoral technique was familiarity with the anatomy.¹⁰ The main disadvantages included lack of sterility around the access site, possible thrombosis or kinking of the sheath and skin injury while resting on the tube during the procedure.¹⁰ The advantage to using radial artery access is its easier accessibility in the prone position, but the main disadvantages include difficulty crossing an elongated aortic arch and accessing the left common carotid artery when approaching from the left.^{10,12} Popliteal artery access, as used in our patients, provides the advantages of both techniques while avoiding their disadvantages. The popliteal access provides comfort to the interventionist as the artery is readily accessible in the prone position. It also offers familiar anatomy, as the catheter is passed into the femoral artery and advanced similarly to a transfemoral approach with simple access to all carotid and vertebral arteries.

Intraoperative DSA for spinal vascular lesions is well described.^{2,12,13,15} Orru et al. described a technique of obtaining femoral access while the patient was in the supine position.¹³ Once the sheath was secured to the lateral thigh, the patient was then flipped prone for the spine surgery.¹³ The catheter was then accessed on the lateral thigh when intraoperative angiography was needed.¹³ Although this is feasible, issues with sheath

thrombosis or kinking can arise.¹⁰ We found intraoperative spinal angiogram helpful to confirm lesion obliteration and to rule out the presence of a vascular lesion. Additionally, we did not have to struggle with access or catheter kinking in our popliteal access.

There are two potential intra-angiogram issues with this approach. The first of which is the length of catheter needed for the procedure. In high thoracic or vertebral injections, patients may require a longer catheter, but in our case series, a catheter longer than the standard 100 cm was never needed. The second potential issue is the closure. Manual compression may be difficult within the popliteal fossa, but we used this method without issue. In one patient, a Femoral Introducer Sheath and Hemostasis (FISH) closure system was used. The benefit of this system is that it does not require angiographic evaluation of the vessel, so placement in the OR is feasible. We did not experience any post-procedure hematomas in any of our patients, independent of whether a closure device was used or not. Other closure devices may also work with this approach, but we do not have experience using them in popliteal access. Overall, this approach is not technically difficult and any trained interventionist should be able to perform this access with ease.

Popliteal access has been used in peripheral vascular interventions.^{3,5,20,21} It was first described by Tonnesen et al. in 1988.¹⁸ This was initially performed for access to the superficial femoral artery and iliac lesions.¹⁸ At 3-year follow-up, there were no differences in complications when compared to other techniques.¹⁸ It has been established as safe for both antegrade and retrograde angiography.^{6,23} Though studies show complications are comparable to other access areas, it still does have associated risk. Trigau et al. used cadaveric and CT analysis of the popliteal anatomy to better understand risks associated with a puncture in the popliteal fossa.¹⁹ He found that the popliteal artery

and vein are contained within a common sheath and the artery lies anteromedial to the vein in 43% of cases, anterior in 40% of cases and anterolateral in 9% of cases.¹⁹ There is concern that with the close proximity of the artery to the vein combined with the difficulty of compression in the popliteal fossa, an arteriovenous fistula could develop after the catheter is removed.¹⁴ Another potential risk of this access technique is critical limb ischemia. Peripheral pulses and lower extremity strength examinations should be monitored closely after the procedure to avoid this potential complication. Authors consistently recommend the use of a micropuncture needle and ultrasound to obtain access to the popliteal artery.^{14,20} We found this technique helpful with our patients and did not experience any major complications in the procedures.

In the case of our patients, popliteal access was used for intraoperative spinal angiograms, but it can also be used for intracranial surgeries when patient positioning is lateral or prone. Certain cranial or craniocervical surgeries require the lateral or prone position. In these surgeries, a non-femoral vascular access point may be more suitable. Nossek et al. described the use of radial access for a cerebellar AVM and tentorial dural AV fistula.¹² In these cases, the authors found radial artery access easily obtained, but did encounter issues with navigation across an elongated aortic arch.¹² Our popliteal approach offers easy access but avoids issue of navigating a difficult aorta in both cranial and spine intraoperative angiograms.

CONCLUSIONS

Popliteal access for intraoperative angiograms in patients positioned lateral or prone provides easy access, familiar anatomy and low risk of complications, both peri-

procedural and long-term. Its use allows for simple confirmation of vascular obliteration in neurovascular surgeries of both the brain and spine.

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FIGURE LEGENDS

Figure 1. Sagittal and axial T2-weighted MR images demonstrate tortuous veins within the thecal sac and increased signal in the thoracic spinal cord (**A** and **B**). Preoperative diagnostic angiogram shows the presence of a dural arteriovenous fistula originating at the level of the right L4 foramen (**C**). Intraoperative angiogram showing interruption of the fistula with the temporary clip (**D**).

Figure 2. Preoperative angiogram showing a dural arteriovenous fistula originating at the T5 level (**A**). Intraoperative angiogram showing residual fistula (**B**). Repeat intraoperative angiogram showing obliteration of the fistula (**C**).

Figure 3. Sagittal and axial T2, as well as sagittal and axial T1 post-contrast of the cervical spine demonstrating syringomyelia and a faintly enhancing mass lesion at the level of the fourth cervical vertebra (**A–D**). Intraoperative angiogram showing normal vasculature of the cervical spine and no sign of dural arteriovenous fistula (**E**).